



**BURNS**  **MCDONNELL**

# **Grid Stability Awareness System (GSAS)**

**- A Software Suite for Stability  
Monitoring and Analysis  
(DOE-OE0000700)**

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# Project Overview

## ▸ Objectives

- Develop a suite of production level software applications (named Grid Stability Awareness System - GSAS) for power grid real-time monitoring and analysis of oscillation stability, voltage stability and transient stability.
- Deploy the software suite to one of Southern Company's control centers

## ▸ Project Duration

- 10/1/2014 - 12/31/2016

## ▸ Funding

- DOE Funds: \$1,458,181 (48.6% of total budget)
- Recipient cost share: \$1,541,936 (51.4% of total budget)

## ▸ Partners

- Southern Company
- Washington State University
- Grid Protection Alliance

# Project Achievements

Developed a software suite: Grid Stability Awareness System - GSAS

- Oscillation monitoring tool
- Voltage stability monitoring tool
- Angle instability monitoring tool
- Angle difference monitoring tool
- Event detection tool

Deployed the software suite on Southern Company's real-time synchrophasor facilities

- Release 1 (11/18/2015), Dashboard, oscillation tool, voltage stability tool
- Release 2 (3/9/2016), Event detection and alarm triggers and archival
- Release 3 (7/27/2016), Angle instability tool, angle difference monitoring tool
- Release 3.1 (8/31/2016), Final release

# Project Achievements (cont.)

Performed extensive off-line validation of analytical engines

- Using transmission planning model
- PSSE simulation of known events
- Validating based on different stability category

Performed comprehensive evaluation of software on-line performance

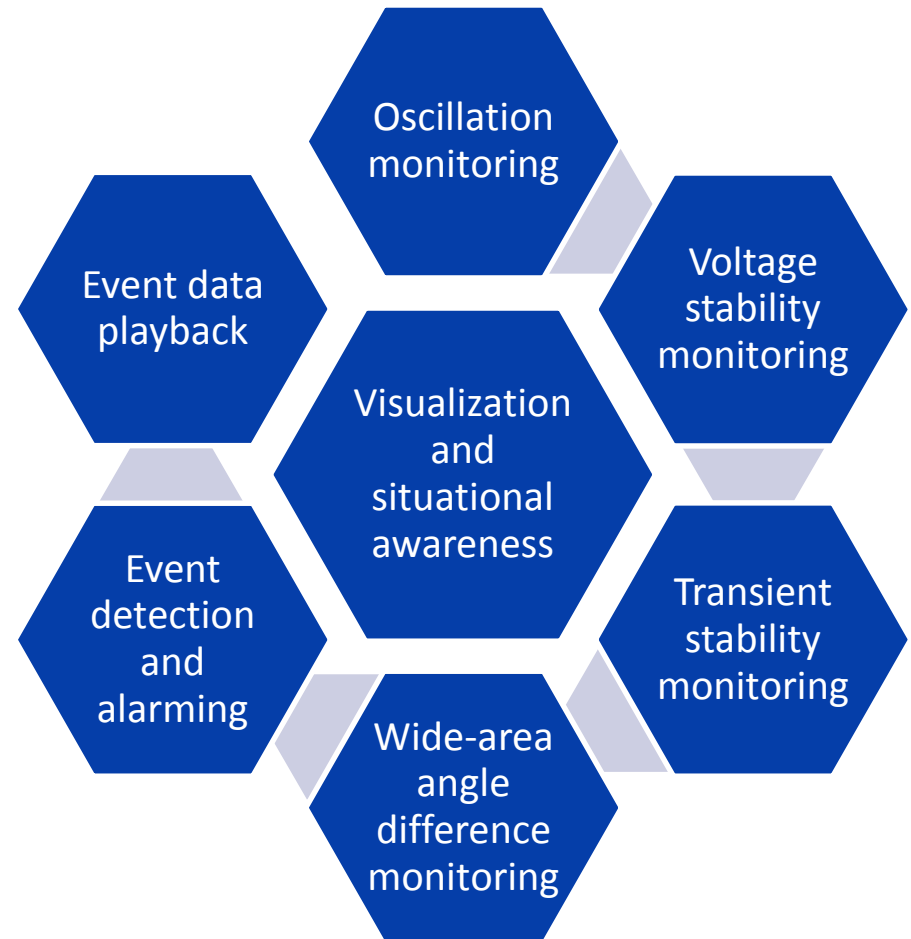
- Bi-weekly WebEx demo to demonstrate software performance based on real-time data
- Receive feedbacks from all stakeholders at the on-line demo
- Address feedbacks quickly

Training materials and training sessions

- Facilitated by off-line validation effort
- For different user groups

# GSAS Design Considerations

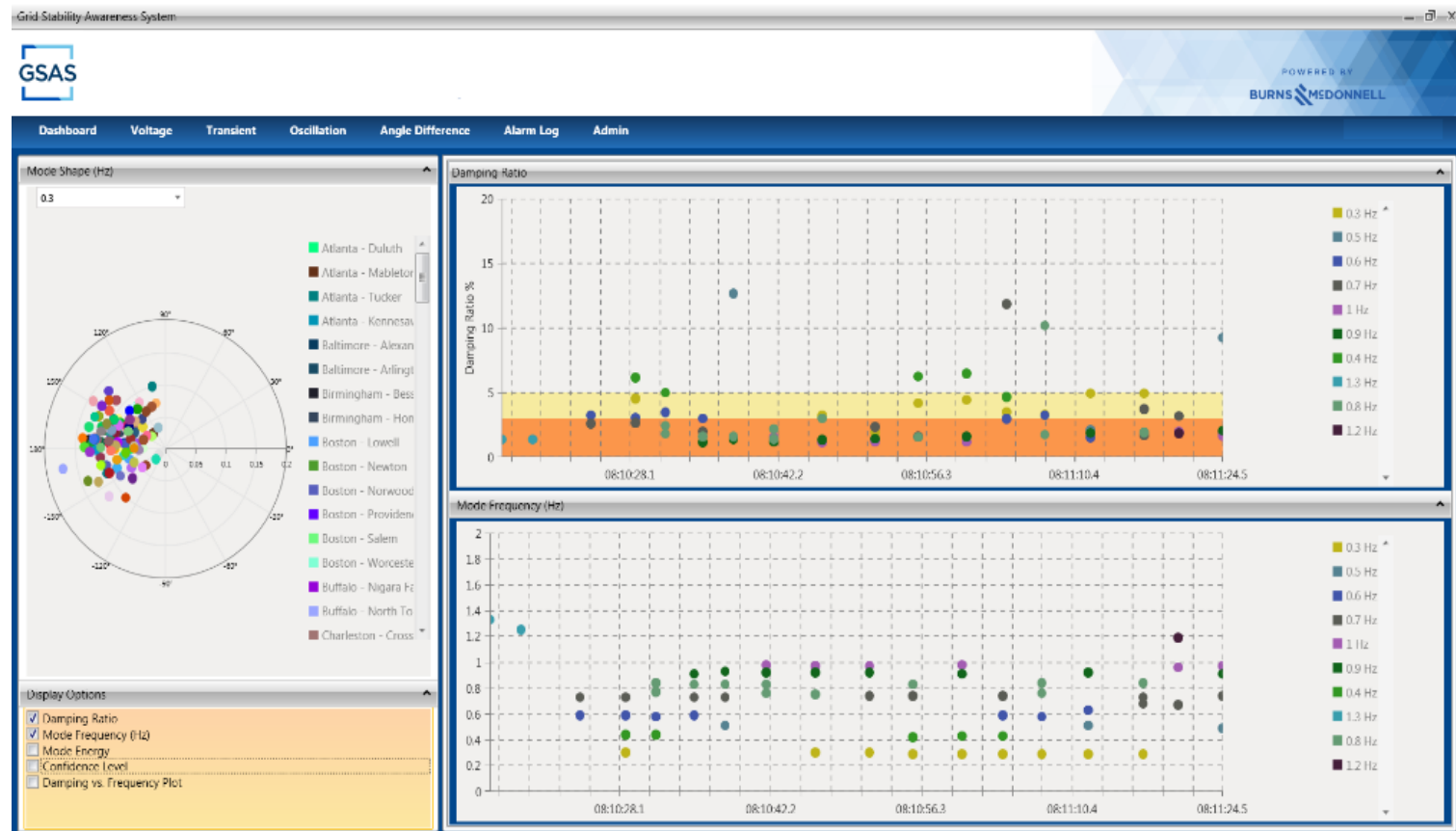
- ▶ Operator view oriented
  - Real-time data streams
  - Event triggers
- ▶ Scalable for larger numbers of PMUs
- ▶ Extensible framework for new functionality
  - Stability monitoring
  - Dynamic response validation
  - Wide-area awareness
- ▶ Server / Client structure



GSAS Modules Implemented

# Oscillation Monitoring

- ▶ Mode frequency, damping ratio, mode energy, confidence level, mode shape for each mode
- ▶ Playback of historical alarm data



(Note: Data displayed is for illustration only.)

# Voltage Stability Monitoring

- ▶ Local/remote voltage stability index and confidence level for each line
- ▶ User selectable signals based on locations and voltage levels
- ▶ Playback of historical alarm data



(Note: Data displayed is for illustration only.)



# Angle Difference Monitoring

- ▶ Angle difference for each user-defined angle difference pair
- ▶ Playback of historical alarm data



(Note: Data displayed is for illustration only.)

# GSAS Alarm Mechanisms

## Oscillation Stability Alarming

- Real time modal analysis (damping ratio, mode frequency, mode shape, mode energy)
- User-configurable damping ratio limit and confidence thresholds

## Voltage Stability Alarming

- Real time voltage stability index based on  $\Delta Q/\Delta V$  sensitivity
- User-configurable voltage stability limits and confidence thresholds

## Transient Stability Alarming

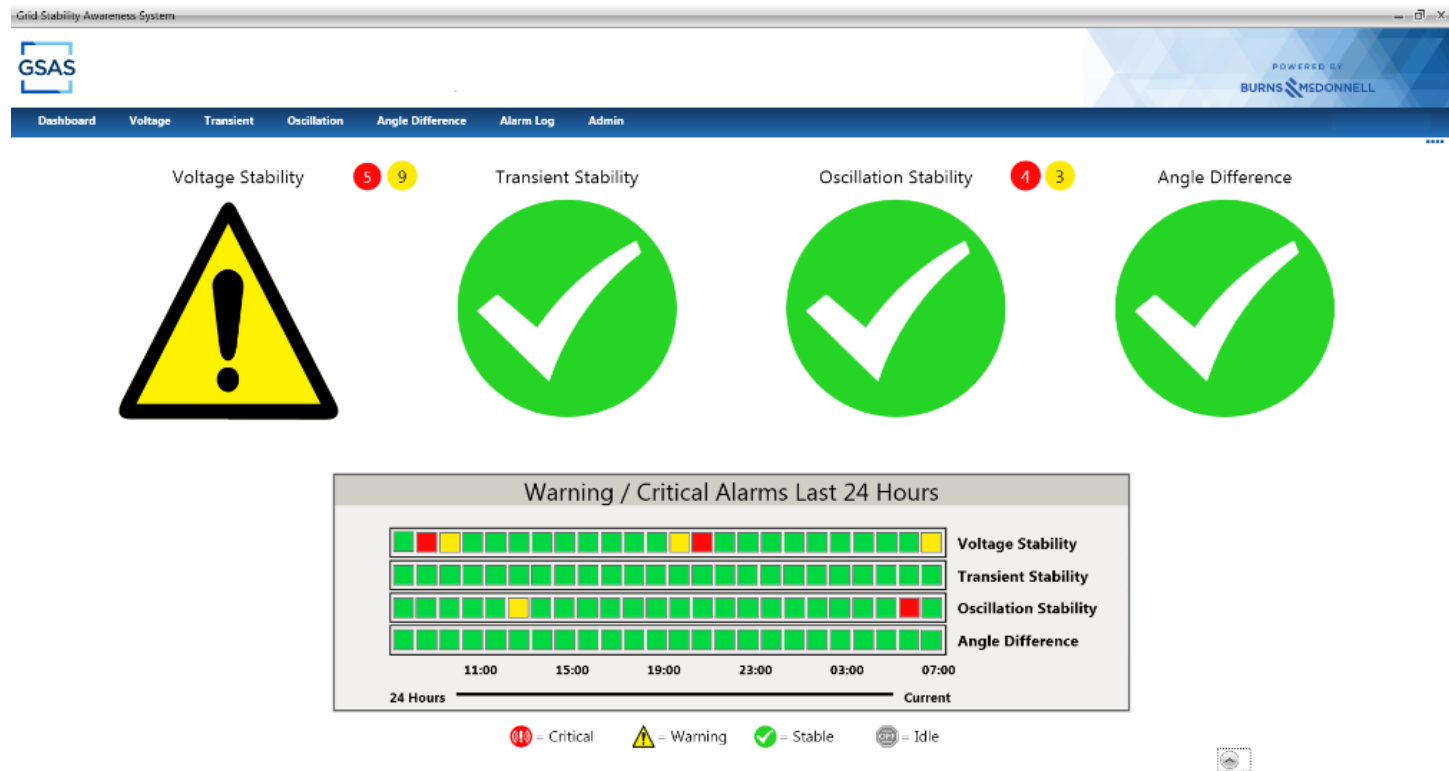
- Real time angle separation after transient event
- User-configurable generator clusters

## Angle Difference Alarming

- Real time phase angle difference
- User-configurable phase angle difference limits

# GSAS Alarming Dashboard

- ▶ Real-time status of system stability
- ▶ Historical (last 24 hours) status of system stability
- ▶ User clickable event/alarm retrieval
- ▶ Event/alarm log and acknowledgements



(Note: Data displayed is for illustration only.)

# Historical Alarm Playback

- ▶ Alarms captured for playback mode (configurable)
- ▶ Alarm logs and operator acknowledgements
- ▶ Alarm filtering, grouping, and report generation
- ▶ Post-event replay and analysis

The screenshot displays the Grid Stability Awareness System (GSAS) interface. At the top, there is a navigation menu with options: Dashboard, Voltage, Transient, Oscillation, Angle Difference, Alarm Log, and Admin. Below the menu, there are tabs for Voltage Alarms, Transient Alarms, Oscillation Alarms, and Angle Difference Alarms. A calendar for August 2016 is shown, with the 26th selected. Search filters are set for 'Search From Date: 8/26/2016 12:00 AM' and 'Search To Date: 8/26/2016 11:59 PM'. A 'Search' button is located below the calendar. The main area contains a table of alarm records.

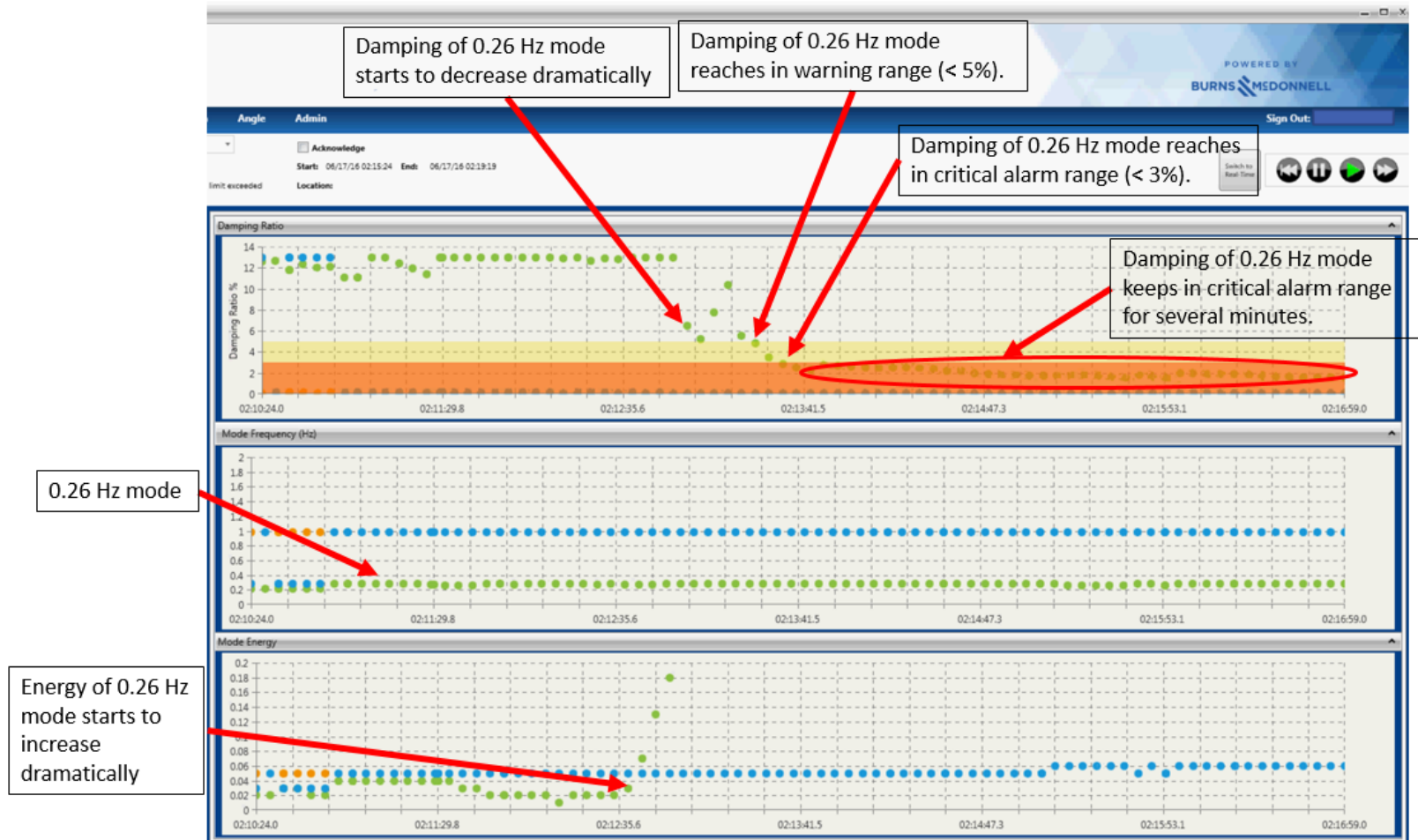
Alarm ID	Severity	Location	Start	End	Alarm Type	Acknowledged By	Acknowledged Date	Message
VSM5400	Warning Alarm	Memphis - Southaven - 230	08/26/16 12:28:19	08/26/16 12:28:38	Remote Voltage Index			Negative stability index exceeds warning alarm
VSM5401	Critical Alarm	Boston - Worcester - 345	08/26/16 12:28:19	08/26/16 12:32:06	Remote Voltage Index			Negative stability index exceeds critical alarm
VSM5402	Warning Alarm	Boston - Worcester - 345	08/26/16 12:28:19	08/26/16 13:00:22	Remote Voltage Index			Negative stability index exceeds warning alarm
VSM5403	Critical Alarm	Boston - Newton - 345	08/26/16 12:28:19	08/26/16 12:32:49	Remote Voltage Index			Negative stability index exceeds critical alarm
VSM5404	Warning Alarm	Boston - Newton - 345	08/26/16 12:28:19	08/26/16 13:00:22	Remote Voltage Index			Negative stability index exceeds warning alarm
VSM5405	Critical Alarm	Boston - Lowell - 345	08/26/16 12:28:19	08/26/16 12:30:01	Remote Voltage Index			Negative stability index exceeds critical alarm
VSM5406	Warning Alarm	Boston - Lowell - 345	08/26/16 12:28:19	08/26/16 12:42:37	Remote Voltage Index			Negative stability index exceeds warning alarm
VSM5407	Warning Alarm	Boston - Providence - 115	08/26/16 12:28:19	08/26/16 12:30:01	Remote Voltage Index			Negative stability index exceeds warning alarm
VSM5408	Critical Alarm	Buffalo - Nigara Falls - 345	08/26/16 12:28:19	08/26/16 13:00:22	Remote Voltage Index			Negative stability index exceeds critical alarm
VSM5409	Warning Alarm	Buffalo - Nigara Falls - 345	08/26/16 12:28:19	08/26/16 13:00:22	Remote Voltage Index			Negative stability index exceeds warning alarm
VSM5410	Critical Alarm	Buffalo - North Tonawanda - 345	08/26/16 12:28:19	08/26/16 12:30:01	Remote Voltage Index			Negative stability index exceeds critical alarm
VSM5411	Warning Alarm	Buffalo - North Tonawanda - 345	08/26/16 12:28:19	08/26/16 12:30:07	Remote Voltage Index			Negative stability index exceeds warning alarm
VSM5412	Warning Alarm	Charleston - St Albans - 230	08/26/16 12:28:19	08/26/16 12:30:01	Remote Voltage Index			Negative stability index exceeds warning alarm
VSM5413	Warning Alarm	Chicago - Oak Lawn - 115	08/26/16 12:28:19	08/26/16 12:29:40	Remote Voltage Index			Negative stability index exceeds warning alarm
VSM5414	Warning Alarm	Chicago - Oak Park - 115	08/26/16 12:28:19	08/26/16 12:30:01	Remote Voltage Index			Negative stability index exceeds warning alarm
VSM5415	Warning Alarm	Chicago - Joliet - 115	08/26/16 12:28:19	08/26/16 12:30:01	Remote Voltage Index			Negative stability index exceeds warning alarm

(Note: Data displayed is for illustration only.)

# Actual Oscillation Event Detected

Event Date: June 17, 2016

This event occurred outside of Southern Company's footprint...



# Project Progress

## ▸ Key Milestones (as of October, 2016)

Milestones	Estimated Completion
Project Kick-off meeting at Southern Company	Complete
An on-site interview meeting at Southern Company	Complete
Draft software requirement specifications	Complete
Define software roadmap and plans for development and deployment	Complete
Develop and refine analytical tools (engines)	Complete
Release 1 of GSAS	Complete
Release 2 of GSAS	Complete
Release 3 of GSAS	Complete
Complete training materials and user manuals	On going
Complete grid operator training sessions	On going
Complete topical report on software off-line validation	On going
Complete topical report on evaluation of software on-line performance	On going

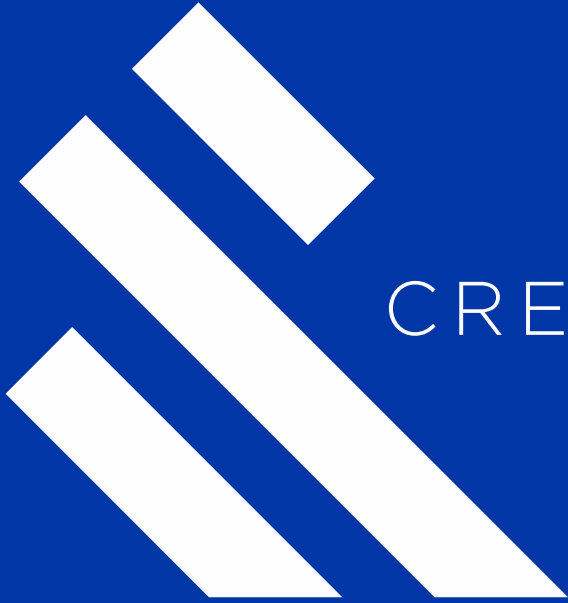
# THANKS

## Contact

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CREATE AMAZING.